Development of Smart Garments and Accessories to Support Behaviour Change in Teen-agers: Considerations on the Use of Interactive Virtual Prototyping

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Abstract—**This paper provides some considerations and preliminary results on research work for the development and experimentation of a behaviour change system to promote healthy lifestyle in teen-agers and prevent the development of lifestyle related disease. Lifestyle-related illnesses are among the top healthcare challenges in Europe. As an example, the rapidly increasing prevalence of overweight and obesity among children and adolescents reflects a global 'epidemic' worldwide. Due to the associated serious medical conditions, it is estimated that obesity already accounts for up to 7% of healthcare costs in the European Union (EU), as well as costs to the wider economy associated with lower productivity, lost output and premature death. Obesity in younger age groups has been recognized as an alarming key predictor for obesity in adulthood, but also entails a number of short-term health complications in juvenile age along with greater risk of social and psychological problems. The rapid development of Information and Communication Technologies (ICT), and in particular mobile technologies, together with their increasing diffusion among the EU populations, offers an important opportunity for facing these issues in an innovative manner introducing the possibility of a new technological framework to re-design the healthcare system model. Starting from and leveraging the work being performed in the course of the EU-funded project "PEGASO", the research focuses on developing solutions for self-managing life-style with specific target on the younger population. More specifically, an important part of the solution is a wearable sensor system for lifestyle monitoring and awareness development, composed of smart garments and bracelets. Due to the core relevance of the system for the overall solution, it is important that their design meets a set of requirements linked to the performance of the system, but also in terms of user requirements. Tapping into the potential of Interactive Virtual Prototyping (IVP) offers the possibility of designing and testing solutions that offer higher user acceptance and market opportunities. This paper briefly examines this potential approach, looking in particular at the fashion sector and how IVP is used, highlighting the additional issues posed by smart garments and accessories.**

Keywords- wearable sensors; smart garments, smart texiles; Interactive Virtual Protityping; lifestyle management, prevention in healthcare.

I. INTRODUCTION

The research leverages the work in progress of the EU Project PEGASO [1], coordinated by Politecnico di Milano. The project addresses the growing epidemic of obesity in the younger population, with focus on prevention. While there is a general agreement that prevention is the only viable strategy – also in economic terms – for the future of healthcare, prevention is also a vague concept, as the object of prevention is undefined. Strategies are therefore very difficult to define, and they must include the economic model for sustainable prevention. Attempts to put this burden on the public health system will remain unanswered, at least in the present economic situation. It is therefore important to develop a culture of prevention that empowers individuals to become co-creators of their healthcare and wellbeing.

The paper focuses on the issue of how to design a solution that offers a compelling user experience and on the tools that can support the design phase: the case of the PEGASO smart garments is considered.

In particular, Section II provides an overview of the current approach in PEGASO, while Section III illustrates how the use of Interactive Virtual Prototyping tools and techniques can support the design of solution that meet the user requirements and expectations. Section IV briefly highlights potential strands for future work and provides some initial conclusions.

II. OVERVIEW OF PEGASO APPROACH TO LIFESTYLE MANAGEMENT AND OBESITY PREVENTION

As mentioned in the Introduction, the project PEGASO Fit-for-Future aims at developing a comprehensive solution for lifestyle management in order to prevent the risk of obesity and related illnesses, targeting the teen-agers population. In order to address this complex issue, a multidisciplinary approach is required, covering:

- Research on current approaches to prevention (including studies on patients' empowerment strategies and approaches);
- Research on behaviour change theories and approaches;
- Research on how technologies (and more specifically wearable technologies) can be used to support behaviour change towards healthy lifestyles and develop a culture of prevention in young people.

Objective of the work is the development of a product/service system that supports young people (teen-agers) in becoming aware of their habits, while learning what healthy lifestyles are, so that healthier habits are developed and sustained in time.

Adopting a practice-centred research, the way to proceed is seemingly straightforward: mobile apps, games and gamification together with wearable sensors to support self-monitoring and development of self-awareness. However,

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the teen-agers, as target users, add some difficulty to the development of a successful solution. Indeed while wearable sensors (bracelets in particular) are meeting with market success with the adult population, their potential is still not fully expressed with the younger population. In order for teen-agers to understand and accept wearing sensors, they have to be positively engaged; they need to feel involved; the solution needs to make them feel part of a community and not set apart as technology nerds or people in need of care.

The current methodological approach is articulated along the following steps:

- Identification of scenarios: through story telling, teen-agers are involved in the development of different lifestyle scenarios, in order to understand which objects and services may exist or may be imagined that can help them develop self-awareness and improve their lifestyles (a scenario design game such as "The thing from the future" can be adapted to this aim [2]);
- User studies are conducted in parallel: these are based on ethnographic approach, to observe what young people do and like, in different socio-economic sectors (different socio-economic situation have significant influence in lifestyles and on the attention to health and well-being);
- Technology studies and development: focus is on mobile technologies and wearable sensors and actuators, including smart garments, bracelets, etc.;
- Development of case studies, with students from high schools, using also mock-ups.

III. USE OF INTERACTIVE VIRTUAL PROTOTYPING

Using Interactive Virtual Prototyping (IVP) has the potential to improve the overall approach to the research described above; in particular, with regard to the technology studies and development, IVP can be successfully applied to the design and development of smart garments and accessories.

Co-creation has already been applied as a potential approach involving teen-agers in focus groups and making use of questionnaires to understand their lifestyles, their approach to health and wellbeing and also their familiarity with technology and wearable sensors. However, during the first year of the project a full adoption of co-design has proven difficult, due to the limited contact with students in the schools and the consequent difficulty of creating a team able to follow the research, participating in a continuous manner in the design process and therefore championing the project with other students.

In particular with regard to the design on the smart T-shirt, it was clear from the start that "fashion" in a wide sense played an important role in user acceptability. Focus groups were conducted using drawings developed by the designers of the research group; few samples of T-shirts were developed based on the results. However, the samples produced were very costly due to having to set-up the production for such a small number of items. Further the wearability of the T-shirts was not exactly what was expected. The "technical" fabric - which had been selected as very suitable for sports apparels - turned out to be very little stretchable reducing significantly the wearability and comfort. Figure 1 below shows the first set of T-shirts developed within the PEGASO project and shown to the students.

Figure 1. Initial set of T-shirts developed in the PEGASO project

The further development of the model was abandoned and it became evident that drawing was not sufficient and that there was a need to be able to feel the fabric.

IVP is therefore an interesting approach and provides suitable tools for delivering a comprehensive user experience on the basis on which a product with high user acceptance and market potential can be developed and understood.

Figure 2 provides a representation of the IVP process, showing how all senses can be leveraged to develop a truly engaging user experience with products.

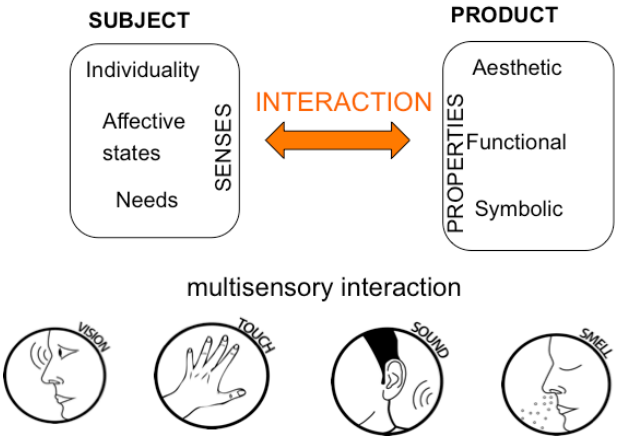

Figure 2. Interactive Virtual Prototyping (source: KAEMaRT Group – Politecnico di Milano)

Virtual prototyping is a method in the process of product development. A Virtual Prototype is an anticipation of a product Shape & Function that does not exist in reality yet, but that appears and behaves as it were real. Virtual Interactive Prototyping simulates how a product looks like, how it works, how users can manipulate and use it, etc.

Virtual Prototyping has been first developed and applied to the manufacturing sector due to pressure to reduce time to

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market. Products are developed in the form of virtual prototypes in which simulation software is used to predict performance prior to constructing physical prototypes. Different design alternatives can be evaluated leading to improvements in performance and design quality.

A. Interactive Virtual Prototyping and Fashion

The user of Interactive Virtual Prototyping in the fashion sector is relatively novel and still presents areas for further study and development. In the course of the project a small search has been performed to understand what is available and which features presents.

Interesting work on IVP for fashion has been carried out at MIRALab – University of Geneva, Switzerland – where many projects have been carried out covering different aspects such as cloth modelling, with the project Virtual Clothing where MIRACloth, a system for building and animating the garments on virtual actors, was developed (see Figure 3), or the projects Fashion Dream (1998) and Dreams of a Model (2004), where real models performed on stage with virtual models, in real time (see Figure 4).

The group has also conducted relevant works in modelling of the human body, as well as in haptic sensing of virtual textile (HAPTEX project, see Figure 5).

[3] and [4] summarise the evolution from modelling clothing to Interactive Fashion Design explaining the different modelling techniques used and how these have been combined.

Politecnico di Milano, with the KAEMaRT group, is also working on applying IVP to the fashion industry [5]. Cooperation with the lab is being investigated to evaluate whether there are tools that can easily be adopted in the project and experimented also with the teen-agers involved.

In the academic environment, many relevant results are available that can be used to develop a user experience in which teen-ager can be engaged in the design of the smart T-shirt, without having to develop costly real prototypes.

Figure 3. Virtual Clothing – use of MIRACloth tool (source MIRALab – University of Geneva)

Figure 4. Project "Dreams of a Model" (source MIRALab – University of Geneva)

Figure 5. Project HAPTEX (source MIRALab – University of Geneva)

On the commercial side tools are available from OPTITEX [6] (Innovative & Easy-to-use 3D Virtual Prototyping + 2D CAD/CAM Pattern & Fashion Design Software), LECTRA [7], TUKATECH [8]. These products are being investigated to see under which conditions they can be used in the academic environment and within the PEGASO project, and its follow up activities, in particular.

With regard to the start garments and accessories, in addition to the issues and characteristics already taken into consideration by the studies and products described above, also the sensing aspect - which are an integral part of the product - needs to be modelled in order to provide the full functionality required for the development of a full user experience.

This means that ideally we would need to model different body shapes in order to position the sensors, so that the body parameters that need to be monitored are correctly acquired. Also the relative position of sensor and data logger as well and the transmission of the sensed signal to the data logger (WES – Wearable Electronic System) may need to be modelled, so that different positions in the clothing could be tested in order to measure how the quality of the signal is affected. This would allow to test different designs of the smart T-shirt, also changing the position of the data logger, creating different designs that are better suited to different

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the sports practised by the students at school and also in sports' teams.

Working with teen-agers the appearance is also very important. The smart T-shirts proposed for the tests performed in December (total black as other designs have proven difficult to get an overall agreement) are produced in stretchable material (which is needed to ensure good contact between the skin and the sensors) that is tight on the body. This makes them of difficult acceptance for people that are overweight and prefer loosely fitting apparels. Given the constraint that the sensors have to be in touch with the skin, using flexible tools to try different designs would help to ensure user acceptance by working with the teens to test different options and validate with them wearability and function.

While there are many open points, and also complex modelling issues, Interactive Virtual Prototyping is a very promising approach to use, also as an engaging technology for the target users that can be involved in co-creation session.

IV. CONCLUSIONS AND FUTURE WORK

The work in the project has involved the target users – students in high schools – since the beginning adopting a user-centred co-design approach. However, traditional methods have been used based in focus groups, trying to abstract general user requirements, which have guided the implementation.

It has to be noted that PEGASO is a wide-ranging project, aiming at a solution of which the wearable sensor system is only a subset. In consideration of the wide scope, the focus groups – though specific to the different elements of the overall solution – in the area of smart clothing and accessories have not been able to provide clear user requirements, taking into consideration the restrictions posed by the sensor system. And indeed the first feedbacks are not very positive, both on the design of the T-shirt (too small, and not useful in a hotter period; the suggestion was for a more summer design) and on the WES, which has to be considered an integral part of the garment – needed for the sensing function but otherwise to be considered as a decorative element (the students indicated that they did not like others to see them using the sensors, which is very visible when lights are on).

The need for a more flexible tool that allows trying different designs and shapes while taking into account the constraints of the sensing system has emerged very strongly from the last tests with the students. Interactive Virtual Prototyping is a promising approach and, although the time limits of the PEGASO project will not allow its full use for the development of the solution that will be tested by the students from June 2016 onward, it can be used in parallel to evaluate alternative designs in view of exploitation of project results.

Further studies in this area will consider fancier types of smart clothes, which are based on, e.g., smart fabrics [9] that can change colour or patterns based on sensed environment or body parameters, including reaction of the fabric to people's skin. Currently we are considering how emotions can be sensed and reflected in clothes appearance. Work has been already performed in this area [10] and can be used for further development that – with an approach based on the Internet of Things philosophy – allows different wearables to connect and communicate with each other. Smart accessories with embedded communication capabilities and smart fabrics are the future of fashion. Designers and virtual prototyping have a very significant role to play in this development. Together with the further evolution of computer graphics and technologies, the capability of modelling the different aspects is the key research issue to be addressed.

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